ANALYTIC AND REPORTING GUIDELINES:
The Third National Health and Nutrition Examination Survey, NHANES III (1988-94)

October, 1996

National Center for Health Statistics
Centers for Disease Control and Prevention
Hyattsville, Maryland

TABLE OF CONTENTS

INTRODUCTION

The National Health and Nutrition Examination Survey (NHANES) is a periodic survey conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC). NHANES III (1988-94) is the seventh in a series of these surveys based on a complex multistage sample design. It is designed to provide national estimates of health and nutritional status of the civilian noninstitutionalized population of the United States aged 2 months and older. Details of the survey design and questionnaires are published in the NHANES III Plan and Operation reference manual (NCHS 1994, U.S. DHHS 1996).

This report presents analytic and reporting guidelines that should be used for most NHANES III data analyses and publications. Section I describes categories and descriptions of key socio-demographic variables that are consistent with the survey design and can be used in analyses of NHANES III data. Section II presents the Census population estimates of the U.S. population that should be used for estimating the number of persons in analytic cells. Section III describes an appropriate procedure for age standardization (age-adjustment) in NHANES III analyses. Section IV presents an overview of the interview and examination response rates, a summary of nonresponse bias analysis, and application of imputation to adjust for item nonresponse.

Section V discusses methods to obtain statistics and associated estimates of standard errors from the NHANES III data. We suggest using SUDAAN (Shah 1995) for computing point and variance estimates from the NHANES III data. However, one can also use other published methods for variance estimation. A summary of alternative methods such as the average design effect approach, balance repeated replication (BRR) methods, or jackknife methods for variance estimation is included in this section.

Finally, a copy of the document "Joint Policy on Variance Estimation and Statistical Reporting Standards for NHANES III and CSFII Reports" is included in Appendix B (LSRO 1995). This guideline was developed by a group of mathematical statisticians from the National Center for Health Statistics of the Centers for Disease Control and Prevention, and the Agricultural Research Service of the U.S. Department of Agriculture (ARS, formerly known as HNIS or Human Nutrition Information Service). Although the report is somewhat technical, there is a very useful table presenting minimum sample size requirements for reporting of findings from the NHANES III.

Because of the complex survey design used in NHANES III, traditional methods of statistical analysis based on the assumption of a simple random sample are not applicable. Detailed descriptions of this issue and possible analytic methods for analyzing NHANES data have been described earlier (NCHS 1985, Yetley 1987, Landis 1982, Delgado 1990). This document summarizes the most recent analytic and reporting guidelines that should be used for most NHANES III analyses and publications. These recommendations differ slightly from those used by analysts for previous NHANES surveys. These suggested guidelines provide a framework to users for producing estimates that conform to the analytic design of the survey.

It is important to remember that the statistical guidelines in this document are not absolute. When conducting analyses, the analyst needs to use his/her subject matter knowledge (including methodological issues), as well as information about the survey design. The more one deviates from the original analytic categories defined in the sample design, the more important it is to evaluate the results carefully and to interpret the findings cautiously.

In the NHANES III, 89 survey locations were randomly divided into 2 sets or phases, the first consisting of 44 and the other, 45 locations. One set of primary sampling units (PSUs) was allocated to the first 3-year survey period (1988-91) and the other set to the second 3-year period (1991-94). Therefore, unbiased national estimates of health and nutrition characteristics can be independently produced for each phase as well as for both phases combined. Computation of national estimates from both phases combined (i.e. total NHANES III) is the preferred option; individual phase estimates may be highly variable. In addition, individual phase estimates are not statistically independent. It is also difficult to evaluate whether differences in individual phase estimates are real or due to methodological differences. That is, differences may be due to changes in sampling methods or data collection methodology over time. At this time, there is no valid statistical test for examining differences between phase 1 and phase 2.

NHANES III is based on a complex multistage probability sample design. Several aspects of the NHANES design must be taken into account in data analysis, including the sampling weights and the complex survey design. Appropriate sampling weights are needed to estimate prevalence, means, medians, and other statistics. Sampling weights are used to produce correct population estimates because each sample person does not have an equal probability of selection. The sampling weights incorporate the differential probabilities of selection and include adjustments for noncoverage and nonresponse. A detailed discussion of nonresponse adjustments and issues related to survey coverage have been published (Ezzati 1993, Ezzati-Rice 1996, Montaquila 1996). With the large oversampling of young children, older persons, black persons, and Mexican Americans in NHANES III, it is essential that the sampling weights be used in all analyses. Otherwise, misinterpretation of results is highly likely. Other aspects of the design that must be taken into account in data analyses are the strata and PSU pairings from the sample design. These pairings should be used to estimate variances and test for statistical significance. For weighted analyses, analysts can use special computer software packages that use an appropriate method for estimating variances for complex samples such as SUDAAN (Shah 1995) and WesVarPC (Westat 1996).

Although initial exploratory analyses may be performed on unweighted data with standard statistical packages assuming simple random sampling, final analyses should be done on weighted data using appropriate sampling weights. A summary of the weighting methodology and the type of sampling weights developed for the NHANES III is included in a report previously published (Mohadjer 1996, U.S. DHHS 1996).

SECTION I
Key variables for analysis

The categories and descriptions for the following selected variables are consistent with the survey design and should be used in analysis, publication, and presentation of the NHANES III data. Also, these descriptions are consistent with the variable descriptions for the NHANES III public release data and the "Variables and Suggested Reporting Categories" that were used for reporting findings in the Third Report on Nutrition Monitoring in the United States (LSRO 1995). These categories and descriptions may be collapsed further for selected analyses, especially when three or more variables are used simultaneously. The collapsed categories defined in this section should be strongly considered for all NHANES III analyses. For example, there are not enough Mexican-American males and females ages 80 years and older to present any findings with confidence. Thus, this age group must be collapsed with the age group 70-79 years, or both sexes combined for ages 80 and older. The same collapsing is recommended for non-Hispanic blacks also. Any exceptions to these guidelines must be used very carefully and there should be substantive reasons for choosing other categories. The following list includes proposed labels and SAS variable names from the NHANES III data file documentation.

Age: HSAGEI and HSAGEU (Age at interview)

Total
2-11 months (DO NOT use < 1 year which includes infants under 2 months)
1-2 years
3-5 years
6-11 years
12-19 years
20-29 years
30-39 years
40-49 years
50-59 years
60-69 years
70-79 years
80 years and older

These age categories are consistent with the NHANES III survey design age groups and should be used in most analyses. Also, collapsing of older age groups for non-Hispanic blacks and Mexican Americans is recommended due to small sample sizes (e.g. 60+, or 70+ years).

NOTE: For adults, use 20 years and older as a summary category and use age 20-74 years for "trends" analyses, since previous NHANES did not include persons greater than 74 years of age. Age groups 20-29, 30-39, 40-49, 50-59 and 60-74 years are suggested for the “trends” analyses with previous NHANES and HHANES (Hispanic HANES). When the sample size is inadequate to show the detailed age groups for adults, 20-39, 40-59, and 60+ years are the preferred age groups.

For youths, the age group 12-19 years will be inadequate for some analyses because of the fact that the Household Adult questionnaire begins at age 17 years and the Household Youth questionnaire ends at age 16 years.

Gender(SEX): HSSEX

Both sexes (codes 1-2)
Male (code 1)
Female (code 2)

For analyses that include only adults, the terms “Men” and “Women” may be used instead of “Males” and “Females”.

Race: DMARACER

All races (or "Total") (codes 1-3)
White (code 1)
Black (code 2)
Other (code 3)

Note: In general, sample sizes for the "Other" race category (code 3) and “Mexican American of unknown race” category (code 8) are inadequate for most analyses and should not be shown separately. Thus, the three reporting categories are: All races, White, and Black. Use of the term "Total" for "All races" is acceptable although it is preferable to use the latter term.

Race-ethnicity: DMARETHN

All race-ethnic groups (or "Total") (codes 1-4)
Non-Hispanic white (code 1)
Non-Hispanic black (code 2)
Mexican American (code 3)
Other (code 4)

Note: When using this variable, code 4 (all other) includes other Hispanics, Asians, and Native Americans. The sample size is too small to be used analytically and the category is too difficult to label. Therefore, this category should be deleted in all tables. However, the "All race-ethnic groups" or "Total" category should include all persons included in the NHANES III.

Education: HFA8R

There are two questions related to education in the household family questionnaire of the NHANES III. The following categorization uses the recoded variable that is based on both questions A7 and A8 (the number of years of education attended and completed) from the Household Family questionnaire.

0-8 years
9-11 years
12 years
13+ years

If the sample sizes in the first two groups are too small, then they may be collapsed into one category 0-11 years (less than high school).

Income: HFF18 and HFF19R

It is unlikely that income can be reported in the detailed categories that it was collected in the interview (question F19 from the Household Family questionnaire). The appropriate categories are:

< $10,000
$10,000-29,999
$30,000-49,999
$50,000 and above

There are a significant number of persons who have a missing value for income(greater than 10%).

An alternative reporting variable for income is question F18 from the Household Family questionnaire. The missing data for this question is less than 2%. However, with only two categories, it will not be useful in many analyses.

< $20,000
$20,000 and above

Poverty index (poverty income ratio, PIR): DMPPIR

This is a calculated variable based on family income and family size using tables published each year by the Bureau of the Census in a series “Current Population reports” on poverty in the United States. This is the best income variable to use when comparing data over time because it is "relatively" standardized for inflation and other factors. However, the method of calculation has been changed slightly over time. The primary reporting categories are:

0.000-0.999	(Below poverty)
1.000 and above	(At or above poverty)

Again, there are a significant number of persons for whom this variable cannot be calculated.

For some specific analyses, use of USDA food assistance program (Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), Food Stamp Program, School Lunch and Breakfast Programs) eligibility cut points of 1.300 or 1.850 is acceptable. The categories to use in these options are:

0.000-1.300	(Low)
1.301-3.500	(Middle)
3.501 and above	(High)

or

0.000-1.850	(Low)
1.851-3.500	(Middle)
3.501 and above	(High)

Region: DMPCREGN (Census region)

Northeast	(code 1)
Midwest	(code 2)
South	(code 3)
West	(code 4)

These four regions are defined by the Census and can be combined as needed in analyses. For example, sample size may be too small for Mexican Americans in the Northeast or the Midwest regions, therefore, codes 1 and 2 can be combined in some analyses.

Metropolitan status(MSA): SDPPMSA (1984 definition of MSA)

MSA
Non-MSA

The terminology, definition, and boundaries of an SMSA (Standard Metropolitan Statistical Area, Census 1980) or MSA (Metropolitan Statistical Area, Census 1990), designated by the Office of Management and Budget based on metropolitan characteristics of a location, were changed between the 1980 and 1990 Census'. For consistency in analyses, we selected the definition of MSA as defined in 1984. This is a variable from a Census file which defines the 1984 MSA status for the survey locations selected in the NHANES III.

SECTION II
Census population estimates

The target (or reference) population for NHANES III, like previous NHANES, is the civilian noninstitutionalized population of the United States. The age group covered by the NHANES III was 2 months and older which was slightly different from the previous NHANES surveys. The midpoints of the phase 1 and phase 2 of NHANES III were March, 1990 and March, 1993, respectively. These dates correspond closely to the date of the 1990 Decennial Census. In addition, four race-ethnicity categories were used in the NHANES III weighting procedures (also recommended for data analysis): non-Hispanic whites, non-Hispanic blacks, Mexican Americans and others. Because no separate estimates are available for Mexican Americans from the 1990 Decennial Census, population control estimates for the civilian noninstitutionalized population from the Current Population Survey (CPS) of March 1990 (table 2.1) and March 1993 (table 2.2) were used to ratio-adjust (post-stratify) the final sampling weights for phase 1 and phase 2 of the NHANES III, respectively. These unpublished CPS estimates are adjusted for undercount of selected minority subdomains of the U.S. population. Thus, phase 1 sampling weights add up to the undercount adjusted March 1990 CPS totals for the civilian noninstitutionalized population of the U.S. (247 million), and phase 2 sampling weights add up to the undercount adjusted March 1993 CPS totals for the civilian noninstitutionalized population of the U.S. (255 million). The corresponding total population for the Census 1990 was 243 million.

The midpoint of the NHANES III was October, 1991. To account for the variation in the U.S. population over two phases, the final NHANES III sampling weights in the combined 6-year sample were computed as one-half of the sampling weights associated with the individual phases. The sum of these final sampling weights (see table 2.3) was 251 million, which was again different from the 1990 Decennial Census population estimate for the civilian noninstitutionalized population. References and more detailed tables with monthly estimate of the U.S. population by age, gender and race-ethnicity including the 1990 Census counts are available on the Internet home page http://www.census.gov under “population estimates” in the section under the topic “A-Z”.

The population estimates presented in tables 2.1-2.3 (unpublished undercount adjusted CPS estimates of the civilian noninstitutionalized population of the U.S.) are the most appropriate totals for the NHANES III, and should be used for calculating the number of persons with a certain condition or disease in the U.S. The CPS population estimate is what was used to calculate the final sampling weights for the NHANES III and is what users will get if the final sampling weights are summed for all sample persons (providing there are no missing data or exclusions). For example, to obtain the total population from the interviewed sample, add final interview weights, WTPEQX6, within the demographic domains among all interviewed persons, and to obtain the total population from MEC examined sample, add the final MEC examination weights, WTPFEX6, among all examined persons within the demographic domains without any exclusions.

Table 2.1: March 1990 undercount adjusted CPS totals

	Other§		Non-Hispanic black		Mexican American	
Age(years)	Male	Female	Male	Female	Male	Female
2-11 months*	1,287,784	1,220,410				
1 to 2**	2,980,860	2,822,836	892,888	866,286	530,908	489,043
3 to 5	4,374,435	4,140,866	911,942	907,764	524,592	533,892
6 to 11	8,629,062	8,152,429	1,737,184	1,706,130	962,604	948,191
12 to 19	11,042,440	10,581,409	2,170,730	2,206,642	1,194,780	1,122,249
20 to 29	15,688,213	16,154,034	2,298,654	2,884,582	1,813,637	1,399,015
30 to 39	16,935,511	17,257,300	2,249,528	2,727,221	1,197,281	1,100,591
40 to 49	13,113,718	13,505,554	1,505,460	1,798,189	688,142	664,344
50 to 59	9,011,922	9,529,197	934,498	1,196,918	367,641	397,611
60 to 69	8,299,588	9,707,882	756,011	1,036,274	247,222	286,985
70 to 79	5,051,094	7,115,632	408,199	618,495	109,853	136,976
80 and over	1,803,494	3,422,850	160,823	301,362	30,777	38,742
18 and over	74,953,106	81,213,937	9,289,883	11,650,404	5,250,589	4,897,286
18 to 39	35,212,726	35,628,856	5,203,821	6,282,854	3,514,531	3,082,745
40 to 59	24,103,817	24,936,741	2,717,786	3,329,443	1,296,774	1,274,973
60 and over	15,636,563	20,648,340	1,368,276	2,038,108	439,283	539,568
All ages	98,218,122	103,610,397	14,025,917	16,249,863	7,667,437	7,117,640
Total	246,889,375					

§ other= persons other than non-Hispanic black or Mexican American
* These totals represent 5/6 of the total white/other population estimate for the infants under 1 year
** Totals for minority children under 3 years represent 17/18 of the total population estimate for the subgroup

Source: Unpublished undercount adjusted population control estimates, Current Population Survey, U.S. Bureau of the Census, U.S. Department of Commerce.

Table 2.2: March 1993 undercount adjusted CPS totals

Age(years)	Other[§] Male	Other[§] Female	Non-Hispanic Black Male	Non-Hispanic Black Female	Mexican American Male	Mexican American Female
2-11 months*	1,220,009	1,195,902				
1 to 2**	3,084,848	2,938,969	987,818	923,857	665,129	597,756
3 to 5	4,524,065	4,268,933	959,781	969,256	601,980	592,474
6 to 11	8,932,943	8,338,142	1,803,866	1,759,779	1,033,780	1,050,243
12 to 19	11,048,058	10,564,791	2,211,922	2,230,171	1,165,540	1,224,296
20 to 29	14,928,357	15,138,441	2,305,254	2,841,098	1,842,996	1,519,812
30 to 39	17,657,521	17,937,053	2,403,677	2,904,261	1,355,338	1,246,844
40 to 49	14,498,177	14,877,962	1,726,460	2,061,222	862,454	794,680
50 to 59	9,605,640	10,058,779	991,326	1,268,221	434,320	480,294
60 to 69	8,107,318	9,350,120	754,936	1,058,620	271,513	330,910
70 to 79	5,474,728	7,453,251	461,172	661,716	122,209	140,951
80 and over	2,054,518	3,844,970	152,168	317,772	45,561	67,707
18 and over	74,953,106	81,213,937	9,289,883	11,650,404	5,250,589	4,897,286
18 to 39	35,212,726	35,628,856	5,203,821	6,282,854	3,514,531	3,082,745
40 to 59	24,103,817	24,936,741	2,717,786	3,329,443	1,296,774	1,274,973
60 and over	15,636,563	20,648,340	1,368,276	2,038,108	439,283	539,568
All ages	101,136,181	105,967,312	14,758,382	16,995,971	8,400,819	8,045,966
Total	255,304,631					

[§] other= persons other than non-Hispanic black or Mexican American
* These totals represent 5/6 of the total white/other population estimate for the infants under 1 year
** Totals for minority children under 3 years represent 17/18 of the total population estimate for the subgroup

Source: Unpublished undercount adjusted population control estimates, Current Population Survey, U.S. Bureau of the Census, U.S. Department of Commerce.

Table 2.3: Population totals from combined 6-year sample by age, gender, and race-ethnicity, NHANES III, 1988-94

Age(years)	Non-Hispanic white		Non-Hispanic black		Mexican American		Other		Total
	Male	Female	Male	Female	Male	Female	Male	Female	population
2-11months	1,087,948	1,022,490	292,652	255,744	188,980	150,760	165,949	185,667	3,350,188
1-2	2,586,688	2,568,738	647,701	639,327	409,038	392,640	446,166	312,164	8,002,463
3-5	3,867,692	3,576,723	935,862	938,510	563,286	563,183	581,558	628,177	11,654,990
6-11	7,808,033	7,401,349	1,770,525	1,732,954	998,192	999,217	972,969	843,937	22,527,176
12-19	9,795,497	9,208,607	2,191,327	2,218,406	1,180,160	1,173,272	1,249,752	1,364,492	28,381,514
20-29	13,340,788	14,032,118	2,194,990	2,776,284	1,785,795	1,462,678	1,967,497	1,614,120	39,174,269
30-39	15,492,738	15,745,424	2,433,567	2,902,296	1,318,832	1,170,452	1,803,778	1,851,752	42,718,838
40-49	12,895,086	12,644,242	1,641,005	1,995,794	795,346	757,632	910,861	1,547,516	33,187,483
50-59	8,551,440	9,112,707	937,867	1,166,482	380,932	410,833	757,342	681,281	21,998,882
60-69	7,740,932	8,915,681	773,533	1,015,525	252,188	326,141	462,520	613,319	20,099,840
70-79	5,033,323	7,049,276	435,122	642,775	116,067	122,989	229,588	235,166	13,864,305
80+	1,857,333	3,545,878	138,000	338,819	45,313	52,006	71,673	88,032	6,137,053
All	**90,057,499**	**94,823,234**	**14,392,149**	**16,622,916**	**8,034,129**	**7,581,802**	**9,619,653**	**9,965,622**	**251,097,002**

Source: The NHANES III data file, 1988-94

SECTION III
Age-adjustment and trends analyses

Age-adjustment is important for trends analyses across NHANES surveys, and also for comparisons across race-ethnic subgroups within NHANES III. It was decided that for comparison of data between NHANES surveys, the 1980 Census population would be used as the standard population (McMillen and Sempos, unpublished memorandum, 1985). Since the choice of a standard population is somewhat arbitrary, for consistency, we recommend that the same standard population from the 1980 Census should be used for all NHANES III analyses and also for trends analyses.

Following are proportions based on the 1980 Census that should be used in analyses consisting of age groups 20 years and older (see table A.1 for the 1980 age distribution, and table A.2 for 1980 civilian noninstitutionalized population counts by single year of age in Appendix A.) In SUDAAN (Shah 1995) these proportions are used with statements STDVAR and STDWGT, where STDVAR lists the name of the variable with age categories used in standardization and STDWGT lists the corresponding proportions from the 1980 Census.

Age Group	**Proportion**
20-29	0.2650
30-39	0.2046
40-49	0.1477
50-59	0.1514
60-69	0.1225
70-79	0.0752
80 +	0.0336

The following proportions based on the 1980 Census data are to be used for trends analyses (ages 20-74 years only) between NHANES surveys.

Age Group	**Proportion**
20-29	0.2834
30-39	0.2188
40-49	0.1579
50-59	0.1618
60-74	0.1781

It is also important to include, when possible, age-specific estimates along with age-adjusted estimates in any publication; so that the user can easily evaluate the possible differences in age-adjusted rates versus crude rates. If it is not possible to report both sets of data in a publication, then the choice of crude (or age-specific) versus age-adjusted data should be made based upon the primary focus of the manuscript.

Furthermore, it is important to remember that the Mexican-American population group is much younger than the non-Hispanic white and non-Hispanic black populations. If the variable of interest varies substantially by age within race-ethnic categories, the age-standardized estimates will be more appropriate for comparison by race-ethnic categories. However, if most of the age-specific estimates are unstable due to small sample sizes (or have high coefficients of variation), then the age-standardized estimate will not be reliable. In general, the above methods for age-adjustment should be used for all NHANES III related analyses. All deviations from these procedures should be documented in the publication so that analyses can be replicated in the future.

SECTION IV
Nonresponse bias analysis and imputation

NHANES III, like most population-based sample surveys based on voluntary participation, experiences both unit and item nonresponse. The unit or total nonresponse generally occurs due to refusal or non-participation by persons selected in the survey. Item nonresponse occurs due to refusal or unwillingness to respond to specific questions or items. In the NHANES III, demographic, socioeconomic, and medical history information are collected through household interviews. After the initial household interview, participants are invited to specially equipped Mobile Examination Centers (MECs) for standardized physical examinations to collect data on physical measurements, physiological tests, and biochemical measurements from blood and urine specimens. Details of the questionnaires and examination components are published in the NHANES III Plan and Operation reference manual (NCHS 1994, U.S. DHHS 1996). Missing data in NHANES III result from unit nonresponse to household interviews and physical examinations, nonresponse to examination component, and item nonresponse due to refusal or non-completion of tests/measurements within examination components. Data are also missing because participants with preselected health conditions were excluded for medical safety from selected examinations.

In NHANES III (1988-94), unit nonresponse to the household interview was 14 percent, and an additional 8 percent did not participate in physical examinations at the MECs. It is common survey practice to compensate for unit nonresponse through weighting class adjustments. A three-stage nonresponse adjustment was used in NHANES III and described in the Weighting and Estimation Methodology report (U.S. DHHS 1996, Mohadjer 1996). In addition to unit nonresponse, NHANES III also experienced numerous levels of item nonresponse. In the household interviews, item nonresponse to specific interview questions ranged from 1-5 percent. The component level nonresponse in the MEC ranged from 1-16 percent. Additional item nonresponse to various measurements within individual examination components ranged from 0-8 percent among examined persons, varying substantially by the age of examinee and type of examination.

The potential for bias increases as the response rate decreases. To achieve higher response rates, NHANES III employed several field procedures including extensive outreach and publicity, and incentives to sample persons such as cash, "certificate of appreciation", and "reports of findings". A guideline to assess the level of nonresponse and evaluate potential bias due to unit and item nonresponse in the NHANES III are published elsewhere (Khare 1995, U.S. DHHS 1994). The report “Accounting for item nonresponse bias in NHANES III” suggests that both weighted and unweighted response rates are important for data analyses. Weighted response rates are more appropriate in examining the potential effect of nonresponse on survey estimates. Since estimates are based on weighted data, weighted response rates provide better clues to potential data quality problems. The magnitude of the weighted response rates should be considered when drawing conclusions from the sample estimates. In the following section, we present findings from the analysis of unit nonresponse to household interview and examinations.

Item nonresponse is generally handled by single or multiple imputation (Kalton 1983, Ezzati-Rice 1994). Imputation methods substitute the missing items with one or more plausible values from similar units in the dataset or with predicted values obtained from a model, thus making it possible to use analytic methods for complete data. Special attention is given to the imputation process, imputed values, and marginal and overall distributions of the data. If imputations are not done carefully, they can introduce more bias instead of reducing bias. In NHANES III, single imputation was done for a few selected items by substituting similar values from other sources within the NHANES III interview or examination. Details of the imputation procedure for imputed variables in the NHANES III are included in the notes section for the associated variable in the documentation of the NHANES III data file.

Additionally, for research purposes, a model-based multiple imputation method was implemented in NHANES III for selected MEC measurements (Schafer 1993, Schafer 1996). This imputed dataset with m=5 imputations will be released separately from the complete NHANES III data and will be available to researchers upon request for special projects. Inquiries can be addressed to the authors listed in Schafer (1993).

Response rates

All persons selected to participate in NHANES III were screened for basic demographic characteristics such as age, gender, and race-ethnicity prior to selection in the sample. Thus, the screening rate for this demographic information was 100 percent with approximately 7 percent of the information obtained from neighbors. Information from two neighbors or "sources" was required before a screener interview was declared "complete" in this situation. All selected persons who completed preselected sections of the household interview questionnaire were defined as interviewed and all interviewed persons who completed one or more examination components in the MEC were defined as MEC examined.

For the first time in NHANES III, frail persons or persons who were unable to come to the MEC were offered an abbreviated physical examination at their home. The home examination was limited to infants and older persons aged 60 years or above. Interviewed persons who completed at least one test or examination at their home were defined as home examined. The home examination included a very small subset of the contents of the MEC examination. Therefore, analysts should be extremely careful in deciding whether a measurement or response to a question collected in the MEC and the home examinations could or could not be combined in analyses. The notes section of the data file documentation includes warning for home examination measurements when they can or can not be combined with the corresponding MEC measurements. Table 4.1 presents a summary description of the NHANES III sample.

Table 4.1: Summary of NHANES III sample at each stage of selection

Number of individual PSUs	81
Number of self-representative PSUs	13
Number of non-self-representative PSUs	68
Number of survey locations	89
Number of area segments	2,114
Number of households screened	93,653
Number of households with SPs	19,528
Number of Sample Persons (SPs)	39,695
Number of interviewed persons	33,994
Number of MEC examined persons	30,818
Number of home examined persons	493

Interview and examination nonresponse

Tables A.3-A.7 in Appendix A present the unweighted and weighted interview and examination response rates by selected socio-demographic characteristics. The weighted response rates were computed using the post-stratified basic weights (inverse of probability of selection). Of the 39,695 persons selected and screened in NHANES III, 14 percent did not participate in the household interview portion and an additional 8 percent were not examined at the MECs (see table A.3). This resulted in 82 percent weighted interview response and 73 percent weighted MEC examination response rates. The primary reasons for nonresponse were refusal or inability to participate. Tables A.4-A.6 show sample sizes, and weighted (using post-stratified basic weights) and unweighted interview and examination response rates by selected socio-demographic characteristics. As shown in tables A.6 and A.7, characteristics of persons who refused the interview or examination varied substantially by age, gender, race-ethnicity, household size, geographic region, and survey location. Table A.7 compares the distribution of selected characteristics among examination respondents and nonrespondents. A large negative difference in proportions within a category indicates a potential for bias due to under-representation of persons in that category.

Interview and examination response rates decreased as age increased. Response rates were lowest among older persons aged 60 years or older. To maximize participation in the NHANES III, multiple persons were selected from a household based on their demographic characteristics. Interview and examination response rates were positively correlated with the household size. Persons living in Northeast urban metropolitan cities had a lower participation rate than persons living in other locations. Non-Hispanic white persons had a lower participation rate than non-Hispanic blacks or Mexican Americans. Non-Hispanic white women aged 80+ years and living alone had the highest nonresponse to the examination.

In addition to 30,818 MEC examined persons, 493 (1 percent) persons (primarily aged 80 years and older) were examined in their home and had an abbreviated physical examination (only for the few components that were included in the Home Exam). Thus, the "MEC plus Home" examined persons sample size increased to 31,311(79 percent) and the overall examination response rate increased by 1 percent. When home examined persons were included in the examined sample, the examination response rate among older persons aged 80 years and above increased by 10 percent.

To reduce potential for bias in estimates due to differential nonresponse by these demographic and geographic characteristics, final interview and examination sampling weights were adjusted for nonresponse using the weighting class adjustment method. In the weighting class adjustment method, first, homogeneous cells were created by using demographic categories defined by age, race/ethnicity, and household size. Then assuming that characteristics of respondents and nonrespondents will be similar in those cells, post-stratified basic weights were adjusted for nonresponse to interview and examinations. At the examination stage, we also adjusted for nonresponse by self reported health status to reduce potential for bias among older persons who reported poor/fair health status in the interview. Also, to reduce bias due to geographic location, sampling weights were ratio-adjusted to the population totals reported by the Census by region and MSA status. Details of the weighting methodology used in the NHANES III are published in a report (U.S. DHHS 1996).

Component and Item nonresponse

In NHANES III, more than 20 different examinations and tests, referred to as components, were conducted in the MECs. These components were assigned to persons based on their age. The component nonresponse varied substantially by demographic characteristics of the participants and the type of component. The primary reasons for non-completion of an examination component was refusal or inability to participate. Also, for medical safety, participants with selected health conditions were excluded from selected examinations (e.g., women with confirmed or suspected pregnancy were excluded from the bone densitometry test). The component nonresponse ranged from 1-16 percent among examined persons and item nonresponse within individual component ranged from 0-8 percent, varying significantly by age.

Table A.8 in Appendix A shows the pattern of nonresponse in MEC components among examined persons. These unweighted rates were computed from an unedited administrative file and are not the actual component completion rates. Final component item nonresponse rates must be computed from the data file for the measurement of interest. Table A.8 shows that phlebotomy, fundus photography of the eye, spirometry, and bone densitometry had the highest non-completion rate. In phlebotomy, non-completion was highest among children under 5 years and among older persons ages 60+ years. Refusal by parents to obtain blood from young children and failure to obtain blood specimen from older persons were the main reasons for the phlebotomy nonresponse. In fundus photography, highest non-completion rate was among older persons because they were unable to hold their head or eye still, or their eyes did not dilate in the allotted time for a good gradable photograph. For the spirometry component, higher non-completion rates occurred because eligible persons either could not blow harder or did not understand the instructions to complete the test. Also, a higher proportion of persons had incomplete spirometry tests because they could not satisfy the preselected criteria for a complete and satisfactory test based on number of reproducible curves. However, a portion of these data are usable in analyses. For bone densitometry, the non-completion rate was highest among women of childbearing age because of the medical safety exclusion. Women with confirmed or suspected pregnancy were excluded from the test.

These analyses show that component nonresponse varied substantially by the demographic characteristics of persons which suggests a potential for bias in some estimates. The potential for bias is greater when the characteristics of participants are different from those of nonparticipants in a survey. Survey estimates should be evaluated for potential nonresponse bias and properly adjusted for nonresponse in order to reduce bias (Ezzati-Rice 1996, Kalton 1986, Rowland 1993). Also, if available, reasons for nonresponse should be taken into account and reported when analyzing data and interpreting results.

SECTION V
Analysis and estimation

Because of the complex survey design used in NHANES III, traditional methods of statistical analysis based on the assumption of a simple random sample are not applicable. A copy of the document "Joint Policy on Variance Estimation and Statistical Reporting Standards for NHANES III and CSFII Reports" is included in Appendix B (LSRO 1995). This guideline was developed by a group of mathematical statisticians from the National Center for Health Statistics of the Centers for Disease Control and Prevention, and the Agricultural Research Service of the U.S. Department of Agriculture (ARS, formerly known as HNIS or Human Nutrition Information Service). Although the report is somewhat technical, there is a very useful table presenting minimum sample size requirements for reporting of findings from the NHANES III. A minimum sample size of 30 is recommended for reporting any mean, proportion, percentile, and variance under the simple random sample assumption. That report also describes how to use the table for complex sample surveys with design effects greater than one (applicable to all NHANES surveys) or for estimating means and other point estimates from highly skewed distributions. It also discusses the special problem of variance estimation from complex survey designs (applicable to all NHANES surveys).

If minimum sample size requirements are satisfied in analytic domains, a confidence interval can be computed using a normal approximation as ($p \pm Z^*s$), where p is the statistic of interest, z is the value of the normal deviate with a selected level of significance (e.g., Z=1.96 can be used for the 95 percent confidence interval), and s is an estimate of the sampling error of p under complex sample design. When sample size is small, Z can be replaced by a value from a t-distribution. For the t-value from a t-distribution and a selected level of significance, n-L degrees of freedom (where n= total number of PSUs with analytic data, and L is the number of strata), can be used in computing the confidence interval (see SUDAAN 1995). Findings from continuing research on issues related to stability of variance estimates and computation of confidence intervals to estimate uncertainty in subdomains of the NHANES III are published elsewhere (Eltinge 1995, Eltinge 1996).

Furthermore, before analyzing the NHANES III data, analysts should conduct simple exploratory analyses to evaluate distribution of the observed data, to identify potential outliers, to assess effect of unit and item nonresponse, and to determine the extent of missing data. We suggest examination of outliers for both data values and sampling weights. Occasionally, extremely large measurement values (that may be valid values) with very large sampling weights can have significant effects on estimates and conclusions. As a general practice, such outliers should be reported and may be excluded from the analyses for valid inferences. Analysts should use their subject-matter knowledge to decide whether to include or exclude these outliers in analyses. When evaluating the extent of missing data, if a large proportion of data is found to be missing, analysts should decide if further adjustments or imputation are needed to compensate for missing information (Kalton 1986).

These suggested guidelines provide a framework to users for producing estimates that conform to the analytic design of the survey. When conducting analyses, the analyst needs to use his/her subject matter knowledge (including methodological issues), as well as information about the survey design. The more one deviates from the original analytic design, of the survey the more important it is to evaluate the results carefully and to interpret the findings cautiously.

Again, we suggest using sampling weights in analyses of the NHANES III data to account for differential probability of selection, nonresponse, and noncoverage. In this section we present methods to compute national statistics and associated estimates of standard errors from the NHANES III data.

Weighting and estimation

The purpose of weighting the sample data is to permit analysts to produce estimates of statistics that would have been obtained if the entire sampling frame (the United States) had been surveyed. Sampling weights can be considered as measures of the number of persons the particular sample observation represents. Weighting takes into account several features of the survey: the specific probabilities of selection for the individual domains that were oversampled, as well as nonresponse and differences between the sample and the total U.S. population. Differences between the sample and the population may arise due to sampling variability, differential undercoverage in the survey among demographic groups, and possibly other types of response errors, such as differential response rates or misclassification errors. Sample weighting in NHANES III was used to accomplish the following objectives:

1. To compensate for differential probabilities of selection among subgroups (age-sex-race-ethnicity subdomains; persons living in different geographic strata sampled at different rates);

2. To reduce biases arising from the fact that nonrespondents may be different from those who participate;
3. To bring sample data up to the dimensions of the target population totals;
4. To compensate, to the extent possible, for inadequacies in the sampling frame (resulting from omissions of some housing units in the listing of area segments, omissions of persons with no fixed address, etc.); and
5. To reduce variances in the estimation procedure by using auxiliary information that is known with a high degree of accuracy.

In NHANES III, the sample weighting was carried out in three stages. The first stage involved the computation of weights to compensate for unequal probabilities of selection (Objective 1 above). The second stage adjusted for nonresponse (Objective 2). The third stage used poststratification of the sampling weights to Census Bureau estimates of the U.S. population to accomplish the third, fourth, and fifth objectives simultaneously. In NHANES III several types of sampling weights(see table 5.1) were computed for the interviewed and examined sample and are included in the NHANES III data file. Also, sampling weights were computed separately for phase 1 (1988-91), phase 2 (1991-94), and total NHANES III (1988-94) to facilitate analysis of items collected only in phase 1, only in phase 2, and over 6 years of the survey. Three sets of pseudo strata and PSU pairings are provided to use with SUDAAN in variance estimation. Users or analysts should use appropriate sampling weights in their analyses (see table 5.1).

Since NHANES III is based on a complex multistage sample design, appropriate sampling weights should be used in analyses to produce national estimates of prevalence and associated variances while accounting for unequal probability of selection of sample persons. For example, the final interview weight, WTPFQX6, should be used for analysis of the items or questions from the family or household questionnaires, and the final MEC examination weight, WTPFEX6, should be used for analysis of the questionnaires and measurements administered in the MEC. Furthermore, for a combined analysis of measurements from the MEC examinations and associated medical history questions from the household interview, the final MEC examination weight, WTPFEX6, should be used. We recommend using SUDAAN (Shah 1995) to estimate statistics of interest and the associated variance. However, one can also use other published methods for variance estimation. Application of SUDAAN and alternative methods such as the average design effect approach, balance repeated replication (BRR) methods, or jackknife methods for variance estimation are discussed in the following section.

Table 5.1: Appropriate uses of the NHANES III sampling weights

Sampling weight	Application
Final interview weight, WTPFQX6	Use only in conjunction with the sample interviewed at home, and only with items collected during the household interview.
Final exam (MEC only) weight, WTPFEX6	Use only in conjunction with the MEC examined sample, and only with interview and examination items collected at the MEC.
Final MEC+Home exam weight, WTPFHX6	Use only in conjunction with the MEC+Home examined sample, and only with items collected at both the MEC and home.
Final Allergy weight, WTPFALG6	Use only in conjunction with the Allergy subsample, and only with items collected as part of the allergy component of the exam.
Final CNS weight, WTPFCNS6	Use only in conjunction with the CNS subsample, and only with items collected as part of the CNS component of the exam.
Final morning exam (MEC only) subsample weight, WTPFSD6	Use only in conjunction with the MEC examined persons assigned to the morning subsample, and only with items collected in the MEC exam.
Final afternoon/ evening exam (MEC only) subsample weight, WTPFMD6	Use only in conjunction with the MEC examined persons assigned to the afternoon/evening subsample, and only with items collected in the MEC exam.
Final morning exam (MEC+Home) subsample weight, WTPFHSD6	Use only in conjunction with the MEC and home examined persons assigned to the morning subsample, and only with items collected during the MEC and home examinations.
Final afternoon/ evening exam (MEC+Home) weight, WTPFHMD6	Use only in conjunction with the MEC and home examined persons assigned to the afternoon/evening subsample, and only with items collected during the MEC and home examinations.

Variance estimation

Total NHANES III estimates

When data are collected as part of a complex sample survey, care is needed to produce approximately unbiased and design-consistent estimates of variances analytically. In a complex sample survey setting, variance estimates computed using standard statistical software packages that assume simple random sampling are biased. The effect of complex sample design on variance estimates is called the design effect. It is defined as the ratio of the variance of a statistic from a complex sample to the variance of the same statistic from a simple random sample of the same size. A design effect of one suggests the equality of the simple random sample variance and the complex sample variance.

When design effects are unstable within domains of interest for a variable, the average design effect for the selected variable is defined as the average of the design effects for that variable from those domains of interest. However, the design effect of a survey is the average of the average design effects for several variables selected from the survey. Design effects in NHANES have traditionally been higher than one, and the magnitude of the design effects has been variable. In NHANES I and NHANES II, the average design effect was about 1.5. Preliminary analyses from NHANES III indicated that the average design effect might be lower (approximately 1.2 or 1.3). However, there are many instances where the design effect is higher. Design effects in the NHANES III vary substantially by variable and domain of interest.

Two common approaches are available for estimation of variances and computing design effects for complex survey data: *linearization and replication*. We recommend using SUDAAN (Shah 1995) for the linearization approach and WesVarPC (Westat 1996) for the replication approach. In the linearization approach, nonlinear estimates are approximated by linear ones for the purpose of variance estimation. The linear approximation is derived by taking the first order Taylor series approximation for the estimator. Standard variance estimation methods for linear statistics are then used to estimate the variance of the linearized estimator.

Following is a sample program in SAS (1990) using SUDAAN to estimate the prevalence of a disease (where the outcome variable MECGSD is coded as 0-1) and the associated standard errors by demographic categories with recoded values of age, sex, and race-ethnicity. This program uses the 6-year data and MEC examination weights WTPFEX6 for computing the national prevalence estimate. *It* *is required for all analyses using SUDAAN to sort the input data by strata (e.g., SDPSTRA6) and PSU pairings (e.g., SDPPSU6) prior to analysis.* Also, all classification variables should be recoded with consecutive numbers starting from number 1 (SUDAAN may produce errors if there are missing category value or category values are coded as zero) and the outcome variable should be recoded to a zero-one variable (or as 0/100 for prevalence in percents) to obtain prevalence as a proportion between 0 and 1. Although PROC CROSSTAB can be used for estimating prevalence and standard errors from categorical data, we used PROC DESCRIPT for computing prevalence in this example.

```
**NOTE: ALWAYS SORT THE INPUT ANALYTIC FILE BY SDPSTRA6 (STRATA) AND
SDPPSU6 BEFORE USING SUDAAN FOR ANALYSES. USE DESIGN=WR AND STRATA AND PSU
VARIABLES IN THE NEST STATEMENT.***;
***************************************************************
LIBNAME MYDAT  'INPUT.DATA.NH3'  DISP=SHR  ; /*INPUT DATA */
PROC SORT DATA= MYDAT.NH3 OUT=FINAL; BY SDPSTRA6 SDPPSU6;
   WHERE WTPFEX6>0; /*SELECT ONLY EXAMINED PERSONS */  RUN;
*******************************************************;
**** SAS PROGRAM TO COMPUTE PREVALENCE OF MECGSD=1/0 ***;
**** IN THE U.S. , DEFF, AND THE ASSOCIATED STANDARD ERRORS ;
*******************************************************;
************START SUDAAN PROCEDURE ************************;
***********************************************************;

PROC DESCRIPT DATA=FINAL  FILETYPE=SAS DESIGN=WR MEANS  DEFF;
NEST  SDPSTRA6 SDPPSU6 / MISSUNIT;
WEIGHT    WTPFEX6 ;
VAR    MECGSD ;   /* ANALYSIS VARIABLE */

SUBGROUP HSSEX   AGEA DMPRETHN ; /* CLASSIFICATION  VARIABLES */
LEVELS     2      5     4      ;
TABLES    DMPRETHN*HSSEX*AGEA;
              /* A TREE-WAY OUTPUT TABLE WITH PREVALENCE*/
 /* PRINTED OUTPUT */
SETENV  LINESIZE=132 LABWIDTH=30 COLWIDTH=12;
RTITLE "TABLE 1.  NHANES III  PREVALENCE ESTIMATES"
    "    FOR GALLSTONE DISEASE  BY AGE, GENDER AND RACE-ETHNICITY" ;
PRINT
DEFFMEAN="DESIGN EFFECT"
NSUM="SAMPLE SIZE"
MEAN="PERCENT"
WSUM="POPULATION SIZE"
TOTAL="TOTAL PREVALENCE"
SEMEAN="STANDARD ERROR"
/ NOHEAD NOTIME     NDIMROW=2
STYLE=NCHS         NSUMFMT=F7.0
WSUMFMT=F10.0      TOTALFMT=F12.2
PERCENTFMT=F9.1   SEPERCENTFMT=F9.2  ;
```

This is only an example. It can not be used exactly as presented here for other analyses. Users should refer to the SUDAAN User's manual (Shah 1995) for details and make changes to the program as required for their analyses. The basic structure, the design option, the nest statement, the weight statement, and style=NCHS in the print statement stay the same.

Information on acquisition of the software package and user's manual can be obtained from the Research Triangle Institute (RTI) or from RTI's Internet home page (http://www.rti.org/).

Replication methods provide a general means for estimating variances for the types of complex sample designs and weighting procedures usually encountered in practice. The basic idea behind the replication approach is to select subsamples repeatedly from the whole sample, to calculate the statistic of interest for each of these subsamples, and then to use the variability among these subsamples or replicate statistics to estimate the variance of the full-sample statistics. See Wolter (1985) and the "weighting and estimation" report (Mohadjer 1996, U.S. DHHS 1996) for further descriptions of both the replication and linearization approaches.

There are different ways of creating replicates from the full sample. Jackknife and balanced repeated replication (BRR) methods are two common procedures for the derivation of replicates. The jackknife procedure retains most of the sample in each replicate, whereas the BRR approach retains about one-half of the sample in each replicate. Rao, Wu, and Yue (1992) report on both the jackknife and BRR procedures for estimating the median for cluster samples. For the combined 6-year sample of the NHANES III, replicate weights were created using Fay's Method, a variant of the balanced repeated replication (BRR) method. For more details on Fay's Method, refer to Judkins (1990).

Fay's Method produced replicate weights for NHANES III by multiplying the full-sampling weights by factors of K=0.3 and 1.7. In studies where quartile estimates and small domain estimates are both of interest, Fay's Method has sometimes been used as a compromise between the jackknife and standard BRR. Judkins (1990) demonstrates that for the estimation of quartiles and other statistics, Fay's Method with K=0.3 does well in terms of both bias and stability.

Fifty two replicate weights are provided in the NHANES III data file for combined 6-year interviewed and MEC examined samples. The PC software, WesVarPC, can be used to analyze NHANES III data using the replicate weights. WesVarPC may be downloaded via the Internet at Westat's home page (http://www.westat.com). Any other replication software (such as V-PLX developed by Bob Fay) that accounts for Fay's Method in the computation of variances can also be used. For specific instructions on using WesVarPC to create replicate weights for other subgroups, refer to "A User's Guide to WesVarPC" (Westat 1995). This manual may also be obtained via the Internet at Westat's home page (http://www.westat.com).

Phase specific estimate

Occasionally, data are available in only one phase of the survey. This occurs because certain data items were collected in one phase of the survey, but not collected in the other phase. In this case a paired (collapsed) strata estimate of variance must be used. This will provide a slight over-estimate of the sampling variance. For the NHANES III survey, paired strata and PSU pairings (SDPSTRA1 and SDPPSU1 for phase 1; SDPSTRA2 and SDPPSU2 for phase 2) for both phases are available on the NHANES III data file. The SUDAAN software can use the pairings directly to produce linearized variance estimates. Also, WesVarPC can be used to create simple replicate weights based on the paired strata and produce BRR variance estimates. Again, no matter what procedure is used for individual phase variance estimates, there will be problems related to the stability of the variance estimates. It is suggested that some generalized variance function technique, such as relative variance curves or average design effect models, be employed to smooth the unstable variance estimates.

Although samples in phase 1 and phase 2 are not statistically independent due to sampling variability, an analyst may want to compare an estimate based only on phase 1 data with the corresponding estimate from phase 2 data. The estimates from phase 1 and phase 2 of NHANES III could also be compared to corresponding estimates from previous NHANES. Each of these applications creates a number of analytic issues. As mentioned earlier, when differences in findings between phase 1 and phase 2 of NHANES III are observed, the user must evaluate whether these differences are real or due to sampling variability. This is also true when comparing NHANES III results with previous NHANES. These differences are further complicated by the need to be sure that observed differences over time are not the result of different data collection methodologies. All of the above circumstances result in special problems for variance estimation. Because this is not how the survey was designed, an additional between-PSU component of variation is artificially introduced and variance estimates from individual phases will be a slight overestimate of the true sampling variances. Furthermore, the degrees of freedom for estimating the variances in individual phases would be reduced by approximately one-half. This makes the variance estimates less stable (i.e., the variance of the variance estimates is increased).

Variance estimation from complex samples such as NHANES III is a complicated process. Because of the estimation techniques used, exact expressions for sampling errors are often not available and approximations must be used. Also, estimates of sampling error are themselves subject to variability. Thus, analysts and users should be careful in analyzing data from complex samples and drawing inferences. It is tempting to treat survey data as if it were derived from a simple random sample; if this were the case then standard methods and software could be employed. However, it must be emphasized that standard statistical analyses based on simple random sampling are generally NOT directly applicable to complex samples.

If topics or methods mentioned in this report are not clear or problems occur with computation, users should seek the help of expert survey statisticians who are familiar with these methods. The software developers for the SUDAAN and WesVarPC can usually be contacted for further assistance with specific applications. ***Again, please consider that (1) sampling weights should be used in estimation to account for sampling variability and to adjust for differential probability of selection of persons in such a complex sample, and (2) the survey design structure should be used to estimate measures of statistical confidence.***

APPENDIX A

Table A.1: 1980 Census Population by age groups

Age groups	U.S. population		
	Proportion (total)	Proportion (20+ years)	Total
Under 1 year	0.0156		3,533,692
1 - 2 years	0.0287		6,493,373
3 - 5 years	0.0419		9,483,880
6 - 11 years	0.0920		20,834,439
12 - 19 years	0.1418		32,113,079
20 - 29 years	0.1803	0.2650	40,839,623
30 - 39 years	0.1392	0.2046	31,526,222
40 - 49 years	0.1005	0.1477	22,759,163
50 - 59 years	0.1030	0.1514	23,325,286
60 - 69 years	0.0833	0.1225	18,870,102
70 - 79 years	0.0512	0.0752	11,591,846
80 years plus	0.0228	0.0336	5,175,100
Total			226,545,805

Source: 1980 civilian noninstitutionalized population of the U.S., U.S. Bureau of the Census, U.S. Department of Commerce.

Table A.2: 1980 Census population by single year of age

Age	Total population	Age	Total population	Age	Total population
Under 1 year	3,533,692	40 years	2,468,083	80 years	723,049
1 years	3,269,557	41 years	2,375,849	81 years	640,276
2 years	3,223,816	42 years	2,325,572	82 years	566,548
3 years	3,179,441	43 years	2,237,108	83 years	527,982
4 years	3,141,748	44 years	2,262,796	84 years	477,178
5 years	3,162,691	45 years	2,242,318	85 years	412,549
6 years	3,109,095	46 years	2,139,385	86 years	350,655
7 years	3,273,052	47 years	2,222,969	87 years	306,906
8 years	3,394,998	48 years	2,163,709	88 years	236,314
9 years	3,760,120	49 years	2,321,374	89 years	213,778
10 years	3,716,530	50 years	2,347,068	90 years	175,900
11 years	3,580,644	51 years	2,295,077	91 years	140,003
12 years	3,518,982	52 years	2,363,152	92 years	101,492
13 years	3,643,189	53 years	2,337,138	93 years	78,233
14 years	3,782,784	54 years	2,367,597	94 years	60,964
15 years	4,059,898	55 years	2,390,440	95 years	46,219
16 years	4,180,875	56 years	2,329,790	96 years	32,789
17 years	4,223,848	57 years	2,312,737	97 years	23,471
18 years	4,251,779	58 years	2,330,373	98 years	16,215
19 years	4,451,724	59 years	2,251,914	99 years	12,385
20 years	4,387,100	60 years	2,160,937	100 years	9,663
21 years	4,285,763	61 years	2,073,764	101 years	5,231
22 years	4,284,351	62 years	2,008,093	102 years	3,886
23 years	4,199,711	63 years	1,931,425	103 years	2,800
24 years	4,161,779	64 years	1,913,402	104 years	2,015
25 years	4,116,218	65 years	1,904,641	105 years	1,573
26 years	3,977,515	66 years	1,813,987	106 years	1,276
27 years	3,931,620	67 years	1,763,637	107 years	1,038
28 years	3,708,968	68 years	1,678,740	108 years	883
29 years	3,786,598	69 years	1,621,476	109 years	852
30 years	3,726,525	70 years	1,516,900	110 years	819
31 years	3,607,610	71 years	1,439,723	111 years	623
32 years	3,712,217	72 years	1,371,235	112+ years	1,535
33 years	3,653,921	73 years	1,261,994		
34 years	2,860,647	74 years	1,208,272		
35 years	2,902,331	75 years	1,111,480		
36 years	2,929,040	76 years	1,028,927		
37 years	2,982,533	77 years	951,774		
38 years	2,598,636	78 years	828,866		
39 years	2,552,762	79 years	872,675	Total	226,545,805

Source: 1980 civilian noninstitutionalized population of the U.S., U.S. Bureau of the Census, U.S. Department of Commerce.

Table A.3: Overall interview and examination response rates, NHANES III, 1988-94

Status	Sample size	Percent	Weighted Percent
Total	39695	100.0	100.0
Not interviewed	5701	14.4	18.2
Interviewed, not examined	2683	6.8	7.5
MEC examined	30818	77.6	73.4
Home examined	493	1.2	0.8

Source: The NHANES III data file, 1988-94

Table A.4: Weighted interview and examination response rates among males and females by age and race-ethnicity, NHANES III, 1988-94

Demographic characteristics	MALE(%)				FEMALE(%)			
	Sample size	Household Interviewed	MEC Examined	MEC+home Examined	Sample size	Household Interviewed	MEC Examined	MEC+home Examined
All	**19166**	**80**	**72**	**73**	**20529**	**83**	**74**	**75**
Non-Hispanic white								
Age group								
2-11 months	650	95	86	89	626	96	88	90
1-2	470	93	87	87	497	94	85	85
3-5	495	90	84	84	540	91	80	80
6-11	543	87	79	79	521	86	80	80
12-19	453	86	79	79	599	86	76	76
20-29	575	78	68	68	649	83	76	77
30-39	658	75	67	67	790	80	74	74
40-49	610	76	68	68	632	82	74	75
50-59	640	72	64	65	694	78	68	68
60-69	749	74	66	67	757	74	62	64
70-79	768	76	63	67	1014	75	59	63
80+	819	80	56	67	1022	78	48	61
ALL	**7430**	**79**	**70**	**71**	**8341**	**82**	**72**	**73**
Non-Hispanic black								
Age group								
2-11 months	177	95	90	91	163	97	95	95
1-2	408	93	88	88	389	96	91	91
3-5	575	92	88	88	600	93	90	90
6-11	655	92	88	88	606	92	90	90
12-19	656	88	83	83	692	90	85	85
20-29	617	85	80	80	749	87	83	83
30-39	670	78	71	71	789	87	82	82
40-49	509	78	71	71	586	81	76	76
50-59	305	79	71	72	354	85	78	79
60-69	420	76	69	70	424	79	69	72
70-79	233	88	76	79	269	79	65	69
80+	77	91	72	77	138	82	56	66
ALL	**5302**	**85**	**79**	**79**	**5759**	**87**	**81**	**82**
Mexican American								
Age group								
2-11 months	204	95	91	91	183	97	93	94
1-2	463	94	89	89	467	95	91	91
3-5	642	94	88	88	689	94	91	91
6-11	644	90	86	86	657	91	87	87
12-19	655	87	82	82	642	90	85	85
20-29	855	87	79	79	799	88	84	84
30-39	633	81	73	73	633	88	83	83
40-49	506	80	76	76	482	83	78	78
50-59	250	80	74	74	254	82	76	76
60-69	443	82	77	78	446	82	76	77
70-79	217	82	68	72	180	78	64	69
80+	83	82	68	75	83	86	66	74
ALL	**5595**	**86**	**80**	**80**	**5515**	**89**	**84**	**84**

Demographic charact-eristics	MALE(%) Sample size	Household Interviewed	MEC Examined	MEC+home Examined	FEMALE(%) Sample size	Household Interviewed	MEC Examined	MEC+home Examined
Other								
Age group								
2-11 months	98	91	83	83	105	99	96	96
1-2	90	92	87	87	55	95	88	88
3-5	87	94	92	92	92	90	88	88
6-11	89	90	87	87	70	91	88	88
12-19	83	90	84	84	107	90	84	84
20-29	99	78	71	71	94	88	80	81
30-39	82	73	67	67	102	79	78	78
40-49	59	69	69	69	85	79	68	68
50-59	54	93	81	81	69	80	80	80
60-69	46	83	79	79	61	76	76	76
70-79	28	63	54	59	47	83	72	80
80+	24	84	65	71	27	77	59	67
ALL	**839**	**82**	**76**	**76**	**914**	**85**	**80**	**80**

Source: The NHANES III data file, 1988-94

Table A.5: Sample size and unweighted interview and MEC examination response rates by age, gender and race-ethnicity, NHANES III, 1988-94

Demographic Characteristics	Total n	Interviewed n	Interviewed %	Examined n	Examined %
Total**	**39695**	**33994**	**86**	**30818**	**78**
Males	19166	16295	85	14781	77
2-11 months	1129	1067	95	982	87
1-2 years	1431	1347	94	1273	89
3-5 years	1799	1675	93	1579	88
6-11 years	1931	1768	92	1665	86
12-19 years	1847	1622	88	1510	82
20-29 years	2146	1801	84	1643	77
30-39 years	2043	1620	79	1468	72
40-49 years	1684	1325	79	1222	73
50-59 years	1249	953	76	852	68
60-69 years	1658	1298	78	1166	70
70-79 years	1246	993	80	823	66
80+	1003	826	82	598	60
Females	20529	17699	86	16037	78
2-11 months	1077	1040	97	979	91
1-2 years	1408	1342	95	1254	89
3-5 years	1921	1790	93	1681	88
6-11 years	1854	1699	92	1621	87
12-19 years	2040	1819	89	1701	83
20-29 years	2291	1982	87	1865	81
30-39 years	2314	1974	85	1860	80
40-49 years	1785	1469	82	1360	76
50-59 years	1371	1105	81	1001	73
60-69 years	1688	1310	78	1143	68
70-79 years	1510	1163	77	928	61
80+	1270	1006	79	644	51
Non-Hispanic white	**15771**	**13085**	**83**	**11283**	**72**
Males	7430	6122	82	5344	72
2-11 months	650	614	94	558	86
1-2 years	470	442	94	412	88
3-5 years	495	454	92	420	85
6-11 years	543	482	89	439	81
12-19 years	453	396	87	363	80
20-29 years	575	452	79	397	69
30-39 years	658	501	76	449	68
40-49 years	610	474	78	428	70
50-59 years	640	472	74	414	65
60-69 years	749	572	76	505	67
70-79 years	768	596	78	489	64
80+	819	667	81	470	57
Females	8341	6963	83	5939	71
2-11 months	626	603	96	558	89
1-2 years	497	471	95	425	86
3-5 years	540	495	92	439	81
6-11 years	521	463	89	427	82
12-19 years	599	519	87	461	77
20-29 years	649	546	84	500	77
30-39 years	790	649	82	598	76
40-49 years	632	527	83	472	75
50-59 years	694	548	79	480	69
60-69 years	757	570	75	480	63
70-79 years	1014	769	76	602	59
80+	**1022**	**803**	**79**	**497**	**49**

Demographic Characteristics	Total n	Interviewed n	Interviewed %	Examined n	Examined %
Non-Hispanic black	**11061**	**9627**	**87**	**9009**	**81**
Males	5302	4574	86	4261	80
2-11 months	177	170	96	161	91
1-2 years	408	385	94	371	91
3-5 years	575	535	93	512	89
6-11 years	655	605	92	577	88
12-19 years	656	579	88	542	83
20-29 years	617	523	85	494	80
30-39 years	670	534	80	492	73
40-49 years	509	404	79	368	72
50-59 years	305	241	79	217	71
60-69 years	420	323	77	292	70
70-79 years	233	205	88	178	76
80+	77	70	91	57	74
Females	5759	5053	88	4748	82
2-11 months	163	157	96	154	94
1-2 years	389	375	96	361	93
3-5 years	600	565	94	542	90
6-11 years	606	556	92	541	89
12-19 years	692	629	91	601	87
20-29 years	749	648	87	625	83
30-39 years	789	685	87	655	83
40-49 years	586	479	82	451	77
50-59 years	354	297	84	272	77
60-69 years	424	331	78	291	69
70-79 years	269	217	81	175	65
80+	138	114	83	80	58
Mexican American	**11110**	**9751**	**88**	**9090**	**82**
Males	5595	4868	87	4500	80
2-11 months	204	193	95	182	89
1-2 years	463	437	94	412	89
3-5 years	642	601	94	564	88
6-11 years	644	598	93	570	89
12-19 years	655	572	87	535	82
20-29 years	855	743	87	677	79
30-39 years	633	522	82	470	74
40-49 years	506	400	79	379	75
50-59 years	250	193	77	179	72
60-69 years	443	366	83	335	76
70-79 years	217	175	81	142	65
80+	83	68	82	55	66
Females	5515	4883	89	4590	83
2-11 months	183	176	96	167	91
1-2 years	467	443	95	418	90
3-5 years	689	647	94	620	90
6-11 years	657	616	94	591	90
12-19 years	642	575	90	548	85
20-29 years	799	703	88	661	83
30-39 years	633	558	88	527	83
40-49 years	482	392	81	370	77
50-59 years	254	204	80	193	76
60-69 years	446	360	81	323	72
70-79 years	180	140	78	119	66
80+	**83**	**69**	**83**	**53**	**64**

** total includes all race-ethnic categories including “other”

Source: The NHANES III data file, 1988-94

Table A.6: Weighted interview and examination response rates by selected demographic characteristics, NHANES III, 1988-94

Demographic Characteristics	Total n	Interviewed n	Interviewed %	Examined %
Total	39695	33994	82	73
Age Groups(Year)				
2-11 months	2206	2107	95	89
1-2	2839	2689	94	87
3-5	3720	3465	91	85
6-11	3785	3467	88	82
12-19	3887	3441	87	80
20-29	4437	3783	82	75
30-39	4357	3594	78	72
40-49	3469	2794	79	72
50-59	2620	2058	77	68
60-69	3346	2608	75	65
70-79	2756	2156	76	61
80+	2273	1832	79	52
Gender				
Males	19166	16295	80	72
Females	20529	17699	83	74
Race\Ethnicity				
NH-White	15771	13085	80	71
NH-Black	11061	9627	86	80
Mexican American	11110	9751	87	82
Other	1753	1531	83	78
Household Size				
1-2	11571	9161	77	65
3-4	15421	13270	82	75
5-6	8480	7638	85	79
>6	4223	3925	91	88
Region				
Northeast	5878	4638	75	65
Midwest	7482	6430	83	76
South	16313	14384	85	77
West	10022	8542	82	74
MSA status				
MSA	32155	27149	81	72
Non-MSA	7540	6840	87	81

Demographic Characteristics	Total n	Interviewed n	Interviewed %	Examined %
Marital Status *				
Married	11943	11407	95	86
Wid/Div/Sep	4514	4427	98	82
Never Married	5598	5385	96	86
Education*				
No School	9011	8957	100	92
High School	19509	18930	96	87
College+	6045	5818	96	86
Family Income *!				
<$10,000	7172	6839	94	84
$10,000-29,999	18874	15872	81	73
$30,000-49,999	8739	6990	76	69
>=$50,000	4910	4293	85	76
Poverty Index*!				
<1	10688	10068	92	86
>=1	29007	23926	80	71
Family stayed at same address*				
<=2 years	12911	12717	98	89
3-5 years	6495	6365	98	89
6+ years	15167	14569	95	84
Any Insurance Coverage?				
Yes	20871	20282	96	86
No	2089	1995	94	88
Any Smokers in household?*				
Yes	12842	12451	96	87
No	21949	21412	97	87
Health status*				
Exc/Very/Good/Good	28464	27862	96	86
Fair/poor	6276	6128	97	83

*Among interviewed persons who completed the family questionnaire; missing data are not shown
!Observed or imputed

Source: The NHANES III data file, 1988-94

Table A.7: Comparison of demographic characteristics of examined and not examined persons among interviewed persons, NHANES III ,1988-94

Demographic characteristics	Total	Examined		Not examined	Difference**	Demographic characteristics	Total	Examined		Not examined	Difference**
	N	N	%	%	%		N	N	%		
TOTAL	39695	30818	78	22							
Age Groups(Year)						Marital Status *					
2-11 months	2206	1961	6	3	3	Married	11943	10270	54	52	3
1-2	2839	2527	8	4	4	Wid/Div/Sep	4514	3669	19	26	-7
3-5	3720	3260	11	5	6	NeverMarried	5598	4924	26	21	5
6-11	3785	3286	11	6	5	Education*					
12-19	3887	3211	10	8	2	No School	9011	8398	27	16	11
20-29	4437	3508	11	10	1	High School	19509	17034	56	63	-7
30-39	4357	3328	11	12	-1	College+	6045	5225	17	21	-4
40-49	3469	2582	8	10	-2	Family Income *!					
50-59	2620	1853	6	9	-3	<$10,000	7172	6233	20	11	9
60-69	3346	2309	7	12	-5	$10,000-29,999	18874	14429	47	50	-3
70-79	2756	1751	6	11	-5	$30,000-49,999	8739	6286	20	28	-8
80+	2273	1242	4	12	-8	>=$50,000	4910	3870	13	12	1
Gender						Poverty Index*!					
Males	19166	14781	48	49	-1	<1	10688	9480	31	14	17
Females	20529	16037	52	51	1	>=1	29007	21338	69	86	-17
Race\Ethnicity						Family stayed at same address*					
NH-White	15771	11283	37	51	-14	<=2 years	12911	11865	39	26	13
NH-Black	11061	9009	29	23	6	3-5 years	6495	5887	19	15	4
Mexican American	11110	9090	29	23	6	6+ years	15301	12957	42	59	-17
Other	1753	1436	5	4	1	Any Insurance Coverage *					
Household Size						Yes	20871	18142	91	93	-2
1-2	11571	7674	25	44	-19	No	2089	1868	9	7	2
3-4	15421	12165	39	37	2	Any Smokers in household *					
5-6	8480	7210	23	14	9	Yes	12842	11498	37	34	3
>6	4223	3769	12	5	7	No	21949	19290	63	66	-3
Region											0
Northeast	5878	3948	13	22	-9	Health status*					
Midwest	7482	5880	19	18	1	Exc/VeryGood /Good	28464	25470	83	76	7
South	16313	13187	43	35	8	Fair/poor	6276	5346	17	24	-7
West	10022	7803	25	25	0					0	
MSA status						Urbanization					
MSA	32155	24464	79	87	-8	0-3, metro	32958	25194	82	87	-5
Non-MSA	7540	6354	21	13	8	4-9,non-metro	6737	5624	18	13	5

*Among interviewed persons who completed the family questionnaire; missing data are not shown
! Observed or imputed
** difference= [examined(%)]- [not examined(%)]; a large negative value suggests an under-representation among examined persons in that category.

Source: The NHANES III data file, 1988-94

Table A.8: MEC component completion rates§ (%) among MEC examined persons by age-group to show pattern of component response, NHANES III, 1988-94

Examination component§ §	Overall completion rate	Completion rate by age-groups (years)									
		2-11 months	1-5	6-7	8-11	12-16	17-19	20-39	40-59	60-74	75+
Allergy	90			89	91	91	92	91	89		
Audio	94			94	94	94	93				
Body Measures	99	100	98	98	99	98	98	99	98	98	97
Bone Density*	92							88	93	92	88
CNS	91							91	91		
Dental	98		97	99	98	97	98	98	97	97	98
Dietary recall	99	99	99	99	99	99	99	99	98	98	97
ECG	95								96	95	91
Fundus Photo**	95								97	95	90
GB Ultrasound	98							98	98	97	
OGTT*	84								87	84	
MEC interview	98	99	99	97	98	97	98	97	97	98	97
Performance Test	96									96	95
Phlebotomy	93		84	89	92	94	94	96	97	98	95
Physician's exam	95	98	97	95	95	93	96	96	96	95	95
Spirometry**	93				96	96	96	95	95	90	83
Urine specimen	98			94	97	97	98	99	98	97	93
Xray	93									94	90

§ Includes complete and satisfactory, unsatisfactory, and incomplete examinations
§ § These response rates are computed among examined persons from an unedite d administrative file. The completion rates may not be exactly the same as the actual component completion rate. Sometimes a large or small proportion of date was recovered during the editing process. These rates are just to show pattern of component response by examination age-groups.
* high medical safety exclusion
** high unsatisfactory examinations

Source: The NHANES III administrative file, 1988-94

APPENDIX B

September 23, 1993

Joint Policy on Variance Estimation and Statistical Reporting Standards on NHANES III and CSFII Reports: HNIS/NCHS Analytic Working Group Recommendations

Below is a summary of the recommendations reached by the Methodological Subcommittee of the HNIS/NCHS Analytic Working Group on the issues of variance estimation and statistical reporting standards. Specific recommendations are underlined, whereas suggested practices are italicized. The implementation of these recommendations and suggestions will vary from survey to survey and, perhaps, from estimate to estimate. Nevertheless, <u>official agency publications should contain a "statistical notes" section describing the variance estimation and statistical reporting standards used therein</u>.

The design-based approach to the estimation and analysis of survey data is assumed here. Unlike model-dependent alternatives, the design-based approach makes few assumptions about the nature of the data being summarized and/or analyzed. Two aspects of the sampling design must be taken into account when using this approach: the sample weights and the complex sample design (stratified, multi-stage sampling). Weights are used in the this approach when estimating mean, medians, and other descriptive statistics as well as analytical statistics like regression coefficients. Both weights and indicators of stratum and primary sampling unit (PSU) membership are used when estimating variances and testing for statistical significance. In general, using statistical weights that reflect the probability of selection and propensity of response for sampled individuals will affect parameter estimates, while incorporating the attributes of the complex sample design (i.e., clustering and stratification) will affect estimated standard errors and thereby test statistics and confidence intervals.

The recommendations for presentation of statistical data that follow arise from the issue of sampling variability, and reflect the random way (in the rigorous statistical sense) in which the sample was selected. Although beyond the scope of this report, a consideration of nonsampling issues such as measurement error, nonresponse bias, and other methodological biases are necessary for any thorough interpretation and evaluation of the validity of survey findings.

Variance Estimation

Average design effect methods are often used to stabilize variance estimates (see section below on unstable standard errors). Moreover, these methods offer a parsimonious way of providing information from which users can calculate standard errors themselves. By a "standard error" we mean the estimated standard deviation of an estimated mean or proportion (prevalence). <u>The decision to use average design effect methods in an agency publication should be made on a survey by survey basis depending on the inherent need for variance stabilization. Such</u>

a method may also be used when estimating proportions and means even when there is no compelling need to stabilize variance estimates (in particular, when the method allows for the parsimonious display of information).

No particular average design effect method is recommended over any other. NCHS's approach of averaging design effects across age groups in a particular demographic group for a particular survey item is reasonable.

Statistical Reporting Standards

GENERAL GUIDELINES - An estimate with a very large coefficient of variation (CV) may be combined with other estimates to create an aggregate with a reasonable small CV (by a "coefficient of variation" we mean the ratio of the standard error of estimate divided by the estimate, expressed as a percent). For that reason, no estimate should be suppressed simply because it is deemed statistically unreliable. Nevertheless, the presence of such an estimate in a published table should be noted. In particular, an estimated mean or proportion in a table of an agency publication should be marked with an asterisk denoting it as potentially unreliable (in a statistical sense) if either the sample size on which it is based is less than a fixed number of individuals or if its CV is greater than some designated value.

ADEQUATE SAMPLE SIZE FOR NORMAL APPROXIMATION - The sample size minimum in the above recommendation should be determined, where practical, to assure the near normality of the estimate. *For means of fairly symmetric populations and proportions based on commonly occurring events (where $0.25 < P < 0.75$), a good rule of thumb is the sample size should be no smaller than a broadly calculated average design effect times 30; otherwise, the estimate should be marked with an asterisk.* By "broadly calculated average design effect," we mean the average of estimated design effects across a broad number of cells. The decision on how broad this collection of cells should be is up to the agency.

A second rule of thumb is needed for asymmetric populations. Let G denote the skewness coefficient for a population ($G = m_3/\sigma^3$, where m_3 is the population's third moment around the mean, and σ^2 the second mean moment) and g be an broadly defined estimate of G. *For means of asymmetric populations, a good rule of thumb is the sample size should exceed $25g^2$ times a broadly calculated average design effect; otherwise, the estimate should be marked with an asterisk*. Many continuous variables, like food intakes, are by their nature very skewed. For these, *the rule of thumb given above may be dropped, but it should made* *clear in accompanying text that some estimated means may not be normally distributed* (and, as a result, there may not be a nearly 95% probability that the difference between an estimated mean and the population mean it is estimating is less than 2 times the standard error of the mean).

THE COEFFICIENT OF VARIATION - *The designated CV value in the above recommendation can be set at the agency's discretion for means and proportions based on commonly occurring events* One goal here is to inform the user that most estimates in a publication have a CV below that level. CV's of 25 and 30 percent have commonly been used in HNIS and NCHS publications.

UNCOMMON OR VERY COMMON EVENTS - It is unlikely that estimated proportions based on uncommon ($P \leq 0.25$) or very common ($P \geq .75$) events will be normally distributed unless the sample size is very large. Moreover, a CV rule is not very informative for such estimates. A rule for estimated proportions that are based on uncommon or very common events that is consistent with the literature and the rules given above for commonly occurring events is that n be sufficiently large that *the minimum of nP and n(1-P) be greater or equal than 8 times a broadly calculated average design effect*. Table 1 spells out the required sample sizes for many proportions given a number of different design effects.

STANDARD ERRORS - A standard error is often used to form a confidence interval around an estimated mean or proportion. Consequently, it would be helpful to provide information on the reliability of an agency's standard error estimates. Rather than forming a solid recommendation, the subcommittee offers the following suggestion: *A directly estimated standard error may be marked with an asterisk in a published table if the sample size on which it is based has less than 30 individuals or if the sampled individual comes from less than 12 variance strata with observations in both primary sampling units*. *Moreover, the estimate to which that standard error applies should also be marked with an asterisk*.

UNSTABLE STANDARD ERRORS - Generally, standard error estimates based on small numbers of paired PSU's (i.e. degrees of freedom) are prone to instability. *The decision as to whether an average design effect method is needed to stabilize standard error estimates should be made on a variable by variable basis*. Practical concerns may mitigate against using an average design effect approach for some variables - "variance smoothing" may have little real effect on the relative size of confidence intervals when the standard error is small relative to the estimated mean or proportion (say, when the CV is less than 5 percent).

ESTIMATING THE POPULATION DISTRIBUTION - There are many continuous biomedical variables for which the population distribution is of interest to users. The population standard deviation is often used as a measure of the dispersion of the observations in a population when the distribution is approximately symmetric. [Note that an estimated population standard deviation, a sample size, and an average design effect are sometimes displayed together in an agency publication. This allows users to calculate the standard error of the corresponding estimated mean by themselves.] Percentiles are often used to describe asymmetric distributions like those associated with dietary intake.

The suggestion for the presentation of population standard deviations is the same as for standard errors - *unless there is a minimum of 30 individuals and at least 12 variance strata with observations in both primary sampling units an estimated population standard deviation should be marked with an asterisk*.

The suggestions for the presentation of percentiles parallels those for proportions: *Medians and other percentiles in middle range (i.e., .25 < P < .75) should be marked with an asterisk when the sample size is less than 30 times a broadly calculated design effect. The quantity values at a tail percentiles, P, (i.e., P ≤ .25 or P ≥ .75) should be marked with an asterisk when the minimum of nP and n(1-P) is less than 8 times a broadly calculated design effect* (see accompanying nomogram). Unlike means, an agency may choose to suppress the publication of percentile values that are based on small numbers of observations or have a high estimated CV.

Substantive as well as statistical considerations play a part in the way in which a population distribution is displayed and interpreted. For example, estimated percentiles for one-day (or many-day) dietary intakes can be misleading, since it is the distribution of long-run or usual dietary intakes that most interests users. Thus, *the distinction between long-run and one-day (or many-day) distributions of dietary intakes must be made clear in the text accompanying any table displaying the estimated percentiles of one-day (or many-day) intakes*. The same distinction should also be made clear for certain biomedical variables like blood pressure and cholesterol level.

Table 1. Recommended sample sizes for analyses of complex survey data, by design effect and specified proportion

Proportion	Design effect 1.0	1.1	1.2	1.3	1.4	1.5	1.6
0.99	800	880	960	1,040	1,120	1,200	1,280
0.95	160	176	192	208	224	240	256
0.90	80	88	96	104	112	120	128
0.85	53	59	64	69	75	80	85
0.80	40	44	48	52	56	60	64
0.75	32	35	38	42	45	48	51
0.56-0.74	30	33	36	39	42	45	48
0.55	30	33	36	39	42	45	48
0.50	30	33	36	39	42	45	48
0.45	30	33	36	39	42	45	48
0.26-0.44	30	33	36	39	42	45	48
0.25	32	35	38	42	45	48	51
0.20	40	44	48	52	56	60	64
0.15	53	59	64	69	75	80	85
0.10	80	88	96	104	112	120	128
0.05	160	176	192	208	224	240	256
0.01	800	880	960	1,040	1,120	1,200	1,280

Proportion	Design effect 1.7	1.8	1.9	2.0	2.5	3.0	3.5
0.99	1,360	1,440	1,520	1,600	2,000	2,400	2,800
0.95	272	288	304	320	400	480	560
0.90	136	144	152	160	200	240	280
0.85	91	96	101	107	133	160	187
0.80	68	72	76	80	100	120	140
0.75	54	58	61	64	80	96	112
0.56-.74	51	54	57	60	75	90	105
0.55	51	54	57	60	75	90	105
0.50	51	54	57	60	75	90	105
0.45	51	54	57	60	75	90	105
0.26-.44	51	54	57	60	75	90	105
0.25	54	58	61	64	80	96	112
0.20	68	72	76	80	100	120	140
0.15	91	96	101	107	133	160	187
0.10	136	144	152	160	200	240	280
0.05	272	288	304	320	400	480	560
0.01	1,360	1,440	1,520	1,600	2,000	2,400	2,800

NOTE: Minimum sample size requirements were adjusted for the relative inefficiency in the sample design by a factor equal to the design effect, where design effect = complex sample variance/simple random sample variance.

For midrange proportions (p greater than 0.25 and less than 0.75), the simple random sample (SRS) minimum sample size is 30.

For extreme proportions (p less than or equal to 0.25 or p greater than or equal to 0.75), the SRS sample size (n) satisfies the following rule: n(p) greater than or equal to 8 and n(1-p) greater than or equal to 8.

REFERENCES

Delgado JL, Johnson CL, Roy I, Trevino FM. Hispanic Health and Nutrition Examination Survey: methodological considerations. Amer J Pub Health 80(suppl.):6–10. 1990.

Eltinge JL, Parsons VL, Jang DS. Differences between "Complex-Design-Based" and "IID-Based" analyses of survey data: Examples from phase 1 of NHANES III. STATS magazine, In press. 1996.

Eltinge JL and Jang DS. Stability measures for within-Primary-Sample-Unit variance estimators under a stratified Multistage Design. Technical report No. 241, Department of Statistics, Texas A&M University , College Station, TX. 1995.

Ezzati TM and Khare M. Nonresponse adjustments in a national health survey. 1992 Proceedings of the Survey Research Methods Section of the American Statistical Association, Washington, D.C., 339-344. 1993.

Ezzati-Rice TM and Khare M. An Evaluation of nonresponse bias in a National Health Survey. Presented at the 7th International workshop on household survey nonresponse, Rome, Italy. Manuscript in press. 1996.

Ezzati-Rice TM, Khare M, Rubin D, Little R, Schafer J. A Comparison of Imputation Techniques in the Third National Health and Nutrition Examination Survey. 1993 Proceedings of the Section on Survey Research Methods. American Statistical Association. 1994.

Judkins DR. Fay's Method for Variance Estimation. Journal of Official Statistics, 6, 3, 223-239. 1990.

Kalton G and Kaspryzk D. The treatment of missing survey data. Survey Methodology, Vol. 12, No. 1, 1-17. Statistics Canada. 1986.

Kalton G. Compensation for missing survey data. Survey Data Institute for Social Research, The University of Michigan, Ann Arbor, Michigan. 1983.

Khare M, Mohadjer LK, Ezzati-Rice TM, Waksberg J. An evaluation of nonresponse bias in NHANES III (1988-91). 1994 Proceedings of the Survey Research Methods section of the American Statistical Association, Alexandria, VA, 949-954. 1995.

Landis JR, Lepkowski JM, Eklund SA, Stehouwer SA. A statistical methodology for analyzing data from a complex survey, the first National

Health and Nutrition Examination Survey. National Center for Health Statistics. Vital Health Stat 2(92). 1982.

Life Sciences Research Office (LSRO), Federation of American Societies for Experimental Biology. Prepared for the Interagency Board for Nutrition Monitoring and Related Research. Third Report on Nutrition Monitoring in the United States: Volume 1. U.S. Government Printing Office, Washington, D.C. 1995.

Mohadjer, L, Montaquila, JM, Waksberg, J, Bell, B, James, P, Flores-Cervantes, I, and Montes, M. National Health and Nutrition Examination Survey III: Weighting and Estimation methodology. Prepared by Westat Inc. for National Center for Health Statistics, Hyattsville, MD, February 1996.

Mohadjer, LK, Waksberg, J. Accounting for item nonresponse bias in NHANES III. Prepared for the National Center for Health Statistics, Westat Inc., MD. 1994.

Montaquila JM, Mohadjer L, Waksberg J, Khare M. A detailed look at coverage in the Third National Health and Nutrition Examination Survey (NHANES III, 1988-94). 1996 Proceedings of the Section on Survey Research Methods. American Statistical Association, Alexandria, VA. In press. 1996.

National Center for Health Statistics. Plan and operation of the third National Health and Nutrition Examination Survey, 1988-94. Vital Health Stat 1(32). 1994.

Rao JNK, Wu CFJ, Yue K. Some Recent Work on Resampling Methods for Complex Surveys. Survey Methodology, Statistics Canada, 18, 3, 209-217. 1992.

Rowland ML, Forthofer RN. Adjusting for nonresponse bias in a health examination survey. Public Health Reports, 1993(3), 380-386. 1993.

SAS Institute Inc., SAS Procedure Guide, Version 6, Third edition, Cary, NC. 1990.

Schafer J, Ezzati-Rice TM, Johnson W, Khare M, Little R, Rubin D. The NHANES III Multiple Imputation Project. 1996 Proceedings of the Section on Survey Research Methods. American Statistical Association, Alexandria, VA. In press. 1996.

Schafer JL, Khare M, Ezzati-Rice TM. Multiple Imputation of Missing Data in NHANES III. Proceedings of the 1993 Annual Research Conference.

U.S. Bureau of the Census. Washington, D.C., 459-487. 1993.

Shah, BV, Barnwell, BG, and Bieler, GS. “SUDAAN User’s Manual: Software for Analysis of Correlated Data”. Research Triangle Institute, RTP, NC. Release 6.04, 1995.

U.S. Department of Health and Human Services (DHHS). National Center for Health Statistics. Third National Health and Nutrition Examination Survey, 1988-94, Plan and Operations Procedures Manuals (CD-ROM). Hyattsville, Md.: Centers for Disease Control and Prevention, 1996. Available from National Technical Information Service (NTIS), Springfield, Va. Acrobat .PDF format; includes access software: Adobe Systems Inc. Acrobat Reader 2.0).

Westat, Inc. A User’s Guide to WesVarPC. Westat, Inc., Rockville, MD. 1996.

Wolter KM. Introduction to Variance Estimation, New York: Springer-Verlag. 1985.

Yetley E, Johnson C. Nutritional applications of the Health and Nutrition Examination Surveys (HANES). Annu Rev Nutr 7:441-63. In: Olsen RE, Beutler E, Broquist HP, eds. Palo Alto, California, Annual Reviews Inc. 1987.